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Product Differentiation, Market Structure and Exchange Rate Passthrough

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**STEPHEN MARTIN
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**Product Differentiation, Market Structure and Exchange Rate
Passthrough**

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Abstract:

The impact of changes in the number of foreign/domestic firms, in the extent of product differentiation, and of use of price-setting vs. quantity-setting behavior on the passthrough of exchange rate fluctuations is examined for trade between oligopolistic markets with and without economies of scale.

I. Introduction

One of the questions addressed in the growing literature on the consequences of imperfect competition for trade flows is the relationship between market structure and the passthrough of fluctuations in exchange rates to domestic prices.

Like Dornbusch [1987, p. 93], we assume an exogenous movement in the nominal exchange rate. This movement causes a change in the relative costs of foreign and domestic firms, leading to a shift of the reaction surfaces of foreign firms and movements along the reaction surfaces of domestic firms. Our model, like that of Dornbusch, allows us to investigate the impact of changes in market concentration (the number of firms) on the magnitude of passthrough effects. We allow foreign goods to be imperfect substitutes or complements for domestic goods, which permits us to examine the way changes in demand relationships affect the passthrough relationship. Extensions of the model examine the impact of price-setting behavior and of economies of scale on exchange rate passthroughs.¹

II. The Basic Model

1. Substitutability Between Domestic and Foreign Varieties

Consider a partial equilibrium model of trade between 2 countries, A and B. There are n_A firms in the country A industry and n_B firms in the country B industry.

We want to treat the case of differentiated products. Starting from the case of linear (inverse) demand with homogeneous products,

$$p = a - Q, \quad (1)$$

a straightforward generalization is to write an inverse demand curve for the variety of a differentiated product group sold by firm A1 in market A as²

$$p_{A1} = a - \left[q_{A1} + \theta \left(\sum_{i=2}^{n_A} q_{Ai} + \sum_{j=1}^{n_B} x_{Bj} \right) \right]. \quad (2)$$

In this specification, θ is a product differentiation parameter. $\theta = 1$ implies that products are perfect substitutes (i.e., reduces to (1)), while $\theta = 0$ means goods are completely independent in demand. $\theta < 0$ covers the case of complementary goods. Without loss of generality, the slope coefficient of q_{A1} is normalized at -1.

With a specification of this kind, it is natural to ask how changes in θ affect market equilibrium. For our specific purpose, it is natural to ask how changes in θ affect the equilibrium passthrough of exchange rate fluctuations to domestic prices. But (2) has the implication that an increase in θ means (a) foreign goods become better substitutes for variety A1; and simultaneously (b) all other domestic varieties become better substitutes for variety A1. The way a change in θ affects the exchange rate passthrough (and, indeed, other structure-conduct-performance relationships) therefore depends on aspects of both domestic and foreign market structure.

To avoid this convolution of demand-side relationships, when we examine substitute goods we generalize (2) to obtain inverse demand curves which permit the degree of substitutability among domestic varieties and the degree of substitutability between domestic and foreign varieties to differ:

$$p_{Ai} = a - \left(q_{Ai} + \theta \sum_{k \neq i}^{n_A} q_{Ak} + \psi \sum_{j=1}^{n_B} x_{Bj} \right), \quad i = 1, \dots, n_A \quad (3a)$$

$$p_{Bj} = a - \left(x_{Bj} + \psi \sum_{i=1}^{n_A} q_{Ai} + \theta \sum_{k \neq j}^{n_B} x_{Bk} \right), \quad j = 1, 2, \dots, n_B. \quad (3b)$$

p_{Ai} is the country A price, and q_{Ai} the country A sales, of country A firm i ; p_{Bj} is the country A price, and x_{Bj} the country A sales, of country B firm j . As in (2), θ is a product differentiation parameter, now specific to domestic varieties, lying between zero and one. ψ , also lying between zero and one, measures the degree of differentiation between domestic and foreign varieties in the country A market. We assume $\theta > \psi$: domestic varieties are better substitutes for one another than are foreign varieties.

We begin with the case of constant marginal cost. This implies that profit-maximizing behavior in each market can be examined separately. We will henceforth focus on country A.

Whether products are strategic substitutes or strategic complements depends on the sign of (for example)

$$\frac{\partial}{\partial q_{Ak}} \left(\frac{\partial \pi_{Ai}}{\partial q_{Ai}} \right) \quad \text{or} \quad \frac{\partial}{\partial q_{Bj}} \left(\frac{\partial \pi_{Ai}}{\partial q_{Ai}} \right) \quad (4)$$

(Bulow, Geanakoplos, and Klemperer [1985]). If derivatives of the form (4) are negative, an increase in a rival firm's sales reduces the marginal profitability of firm Ai . The varieties are then strategic substitutes. If the derivatives are positive, an increase in a rival firm's sales increases the marginal profitability of firm Ai . For the linear inverse demand curves (3) and constant marginal cost, these derivatives are negatively proportional to θ (if the outer derivative is with respect to a domestic variety) or ψ (if the outer derivative is with respect

to a foreign variety). This specification has two advantages. First, demand and strategic substitutability (complementarity) coincide. Second, strategic complementarity ($\psi < 0$) is not ruled out with linear demands, in contrast with the case of linear demand curves and homogeneous commodities (see Kirman and Philips [1992, p. 4]).

2. Demand Curves

Let the country A currency be pounds, the country B currency be dollars, and the exchange rate e the number of pounds per dollar. An increase in e therefore represents a depreciation of the country A currency.

Let c_A be the marginal cost of a country A firm, measured in pounds, and c_B the marginal cost of a country B firm, measured in dollars. t_{BA} is unit tariff and transportation cost, also measured in dollars, incurred shipping from B to A. $c_B + t_{BA}$ is the marginal cost of a country B firm to supply a unit of output to country A. In what follows, we assume $a > c_A$ and $a > e(c_B + t_{BA})$.

Firm A_i 's pound profit in country A is

$$\pi_{Ai} = (p_{Ai} - c_A)q_{Ai} \quad (5)$$

The dollar profit of country B firm B_j from sales in country A is

$$\pi_{Bj} = \frac{1}{e}(p_{Bj} - z)x_{Bj} \quad (6)$$

where for notational convenience we write $z = e(c_B + t_{BA})$.

III. Quantity-setting firms

1. Reaction Functions

Consider first the case of substitute goods: $\theta > \psi > 0$. Substituting from the inverse demand curve (3a) in (5) gives an expression for firm Ai 's profit in terms of its own output and the outputs of other firms. Maximization of this expression with respect to q_{Ai} gives the equation of firm Ai 's quantity reaction function in country A:

$$2q_{Ai} + \theta \sum_{k \neq i}^{n_A} q_{Ak} + \psi \sum_{j=1}^{n_B} x_{Bj} = a - c_A. \quad (7a)$$

In the same way, firm Bj 's quantity reaction function in country A is

$$2x_{Bj} + \psi \sum_{i=1}^{n_A} q_{Ai} + \theta \sum_{k \neq j}^{n_B} x_{Bk} = a - c_B. \quad (7b)$$

Now impose country-specific symmetry: since all country A firms produce with the same cost, and all country B firms produce with the same cost, in equilibrium $q_{Ai} = q_A$ and $x_{Bj} = x_B$. By imposing these conditions outside of equilibrium, it becomes possible to graph condensed reaction curves that determine country A equilibrium. The equations of the condensed reaction curves are

$$[2 + (n_A - 1)\theta]q_A + n_B\psi x_B = a - c_A \quad (8a)$$

$$n_A \psi q_A + [2 + (n_B - 1)\theta]x_B = a - z. \quad (8b)$$

They are graphed in Figure 1.

Two types of conditions must be met for the condensed reaction functions to have the indicated configuration, implying positive equilibrium outputs for firms of both countries. For the country A reaction curve to be steeper than the country B reaction curve, it must be that

$$DETI = (2 - \theta)[2 + (n_A + n_B - 1)\theta] + n_A n_B (\theta^2 - \psi^2) > 0. \quad (9)$$

For the intercepts of the reaction curves to have the indicated relationship, it must be that

$$[1 + (n_B - 1)\theta](a - c_A) - \psi n_B (a - z) > 0 \quad (10a)$$

$$[1 + (n_A - 1)\theta](a - z) - \psi n_A (a - c_A) > 0. \quad (10b)$$

2

These conditions are met provided that there is positive demand for each variety if all varieties price at marginal cost,³ which we henceforth assume.

Equilibrium sales are

$$q_A = \frac{[2 + (n_B - 1)\theta](a - c_A) - \psi n_B (a - z)}{DETI} \quad (11a)$$

$$x_B = \frac{[2 + (n_A - 1)\theta](a - z) - \psi n_A(a - c_A)}{DETI} \quad (11b)$$

Country-specific symmetry implies that in equilibrium all country A firms will charge the same price and all country B firms will charge the same price. Substituting from (11) into the equations of the inverse demand curves, we obtain country A equilibrium prices for Cournot quantity-setting oligopoly with imperfectly substitutable goods:⁴

$$p_A = c_A + \frac{[2 + (n_B - 1)\theta](a - c_A) - n_B\psi(a - z)}{DETI} \quad (12a)$$

$$p_B = z + \frac{[2 + (n_A - 1)\theta](a - z) - n_A\psi(a - c_A)}{DETI} \quad (12b)$$

2. Exchange Rate Comparative Statics

Exchange rate fluctuations translate into proportional fluctuations in $z = e(c_B + t_B)$.

From (12),

$$\frac{\partial p_A}{\partial z} = \frac{n_B\psi}{DETI} > 0 ; \quad (13)$$

$$\frac{\partial p_B}{\partial z} = 1 - \frac{2 + (n_A - 1)\theta}{DETI} \quad (14)$$

A little algebra shows that

$$1 > \frac{\partial p_B}{\partial z} > 0. \quad (15)$$

For substitute goods, a depreciation of the home-country currency results in a partial increase in the price of foreign goods and what might be termed a sympathetic increase in the price of competing domestic goods. From (13) and (14), we obtain

$$\frac{\frac{\partial p_B}{\partial z} - \frac{\partial p_A}{\partial z}}{\frac{(2 - \theta)[2 + (n_A + n_B + 1)\theta] + n_B[1 + n_A(\theta + \psi)](\theta - \psi)}{DETI}} > 0. \quad (16)$$

An increase in e leads to a relative increase in price of foreign goods.

The magnitude of passthrough effects depends on n_A , n_B , θ , and ψ . From (13),

$$\frac{\partial}{\partial n_A} \left(\frac{\partial p_A}{\partial z} \right) = - \frac{n_B \psi}{DETI^2} [(2 - \theta)\theta + n_B(\theta^2 - \psi^2)] < 0; \quad (17a)$$

$$\frac{\partial}{\partial n_B} \left(\frac{\partial p_A}{\partial z} \right) = \psi \frac{(2 - \theta)[2 + (n_A - 1)\theta]}{DETI^2} > 0; \quad (17b)$$

$$\frac{\partial}{\partial \theta} \left(\frac{\partial p_A}{\partial z} \right) = - 2 \frac{n_B \psi}{DETI^2} [n_A + n_B - 2 + \theta(n_A - 1)(n_B - 1)] < 0; \quad (17c)$$

$$\frac{\partial}{\partial \psi} \left(\frac{\partial p_A}{\partial z} \right) = n_B \frac{(2 - \theta)[2 + (n_A + n_B - 1)\theta] + n_A n_B (\theta^2 + \psi^2)}{DET1^2} > 0. \quad (17d)$$

As the number of domestic firms increases, the number of firms in the market whose relative costs are not directly affected by exchange rate fluctuations goes up and the magnitude of the passthrough of exchange rate fluctuations to the prices of domestic varieties goes down. Among the other effects which may be laid at the feet of a concentrated market is an enhanced sensibility to exchange rate fluctuations. On the other hand, an increase in n_B increases the passthrough to prices of domestic varieties because it increases the number of varieties whose relative costs are directly affected by exchange rate fluctuations.

As θ increases, domestic varieties become better and better substitutes one for another. As a result, the common equilibrium price of domestic varieties falls toward c_A . This means that there is less of a range within which exchange rate fluctuations can affect prices of domestic varieties. As ψ increases, foreign varieties become better substitutes for domestic varieties, so exchange rate fluctuations have a greater impact on p_A . The fact that (17c) and (17d) are of opposite sign explains why $\partial p_A / \partial \theta$ is of ambiguous sign if θ and ψ are constrained to be equal.

As regards the passthrough to the country A price of country B varieties, we have from (14),

$$\frac{\partial}{\partial n_A} \left(\frac{\partial p_B}{\partial z} \right) = - \frac{n_B \psi^2 (2 - \theta)}{DET1^2} < 0; \quad (18a)$$

$$\frac{\partial}{\partial n_B} \left(\frac{\partial p_B}{\partial z} \right) = [2 + (n_A - 1)\theta] \frac{\theta(2 - \theta) + n_A(\theta^2 - \psi^2)}{DEI^2} > 0 ; \quad (18b)$$

$$\frac{\partial}{\partial \theta} \left(\frac{\partial p_B}{\partial z} \right) = \frac{(n_A - 1)n_A n_B \psi^2 + [2 + (n_A - 1)\theta](n_B - 1)}{DEI^2} > 0 ; \quad (18c)$$

$$\frac{\partial}{\partial \psi} \left(\frac{\partial p_B}{\partial z} \right) = 2n_A n_B \psi \frac{2 + (n_A - 1)\theta}{DEI^2} > 0 . \quad (18d)$$

As the number of domestic firms increases, or the number of foreign firms decreases, the impact of exchange rate fluctuations on the prices of foreign varieties decreases. As domestic varieties become better substitutes one for another, and as foreign varieties become better substitutes for domestic varieties, the magnitude of $\partial p_B / \partial z$ goes up.

IV. Complementary Goods

1. The Model

We examine the case in which all domestic varieties are substitutes, all foreign varieties are substitutes, but foreign and domestic varieties are complements.⁵ For expositional convenience, we substitute $\phi = -\psi$ in the demand curves (3). ϕ lies between zero and one, and is the degree of complementarity between domestic and foreign goods. An increase in ϕ means an increase in the complementarity between foreign and domestic varieties.

2. Exchange Rate Comparative Statics

When foreign and domestic varieties are complements, the condensed reaction curves of quantity-setting firms slope upward. The slope and intercept conditions for the existence of positive equilibrium outputs for firms in both countries are derived in a straightforward way. Equilibrium prices are

$$p_A = c_A + \frac{[2 + (n_B - 1)\theta](a - c_A) + n_B\phi(a - z)}{DETI} \quad (19a)$$

$$p_B = z + \frac{[2 + (n_A - 1)\theta](a - z) + n_A\phi(a - c_A)}{DETI} \quad (19b)$$

Thus

$$\frac{\partial p_A}{\partial z} = - \frac{n_B\phi}{DETI} < 0 ; \quad (20)$$

$$\frac{\partial p_B}{\partial z} = 1 - \frac{2 + (n_A - 1)\theta}{DETI} \quad (21)$$

The signs of the comparative static partial derivatives (17b), (17c), and (17d) are reversed.

The sign of (17a) is positive if $\theta^2 \geq \phi^2$. (18a) remains negative, and (18d) remains positive if $\theta^2 \geq \phi^2$. (18c) and (18b) change sign.

V. Price-setting firms

1. The Model

To model price-setting firms, it is necessary to solve the system of inverse demand curves and obtain the implied demand curves. As suggested by (5) and (6), it is convenient to express the quantity demanded as a function of deviations of price from marginal cost. For notational compactness, we will write

$$p_{Ai}^* = p_{Ai} - c_A \quad p_{Bj}^* = p_{Bj} - z, \quad (22)$$

where $z = e(c_B + l_{Bd})$.

Demand curves are then (see Appendix)

$$\begin{aligned} (1 - \theta)Dq_{Ak} = & \{[1 + (n_B - 1)\theta](a - c_A) - n_B\psi(a - z)\} + \left(\theta + n_B \frac{\theta^2 - \psi^2}{1 - \theta}\right) \sum_{i=k}^{n_A} p_{Ai}^* \\ & + \psi \sum_{j=1}^{n_B} p_{Bj}^* - [1 + (n_A + n_B - 2)\theta + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta}] p_{Ak}^* \end{aligned} \quad (23a)$$

$$\begin{aligned} (1 - \theta)Dx_{Bk} = & \{[1 + (n_A - 1)\theta](a - z) - n_A\psi(a - c_A)\} + \left(\theta + n_A \frac{\theta^2 - \psi^2}{1 - \theta}\right) \sum_{j=k}^{n_B} p_{Bj}^* \\ & + \psi \sum_{i=1}^{n_A} p_{Ai}^* - [1 + (n_A + n_B - 2)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta}] p_{Bk}^* . \end{aligned} \quad (23b)$$

where

$$D = (1 - \theta)[1 + (n_A + n_B - 1)\theta] + n_A n_B \frac{\theta^2 - \psi^2}{1 - \theta} > 0. \quad (24)$$

2. Reaction Functions

Return to the case of substitute varieties. Using the demand curves (23a) and (23b) to express profits (5) and (6) in terms of prices, the equations of the price reaction curves of firms A1 and B1 are

$$\begin{aligned} 2 \left[1 + (n_A + n_B - 2)\theta + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right] (p_{A1} - c_A) \\ - \left(\theta + n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right) \sum_{i=2}^{n_A} (p_{Ai} - c_A) - \psi \sum_{j=1}^{n_B} (p_{Bj} - z) = \\ [1 + (n_B - 1)\theta](a - c_A) - \psi n_B (a - z) \end{aligned} \quad (25a)$$

and

$$\begin{aligned} 2 \left[1 + (n_A + n_B - 2)\theta + n_B(n_A - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right] (p_{B1} - z) \\ - \psi \sum_{i=1}^{n_A} (p_{Ai} - c_A) - \left(\theta + n_A \frac{\theta^2 - \psi^2}{1 - \theta} \right) \sum_{j=2}^{n_B} (p_{Bj} - z) = \\ [1 + (n_A - 1)\theta](a - z) - n_A \psi (a - c_A) \end{aligned} \quad (25b)$$

respectively.

Imposing country-specific symmetry in (25), we obtain the equations of condensed price-reaction functions for country A firms and country B firms in country A:

$$\left[2 + (n_A + 2n_B - 3)\theta + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right] (p_A - c_A) - n_B \psi (p_B - z) = [1 + (n_B - 1)\theta](a - c_A) - \psi n_B (a - z); \quad (26a)$$

$$\left[2 + (2n_A + n_B - 3)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right] (p_B - z) - n_A \psi (p_A - c_A) = [1 + (n_A - 1)\theta](a - z) - n_A \psi (a - c_A). \quad (26b)$$

The condensed reaction curves are graphed in Figure 2. From (23), the intercepts of the reaction curves with the lines $p_B = z$, $p_A = c_A$ have the indicated configuration provided that there is positive demand for each variety if all varieties price at marginal cost.

The existence of equilibrium requires that the slope of the country A firm reaction function be greater than 1, while the slope of the country B firm reaction function is less than one. This requires that

$$DET2 = \left[2 + (n_A + 2n_B - 3)\theta + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right] \left[2 + (2n_A + n_B - 3)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right] - n_A n_B \psi^2 > 0. \quad (27)$$

which we henceforth assume.

3. Exchange Rate Comparative Statics

From (26), one obtains the equilibrium prices when firms set prices:

$$DET2(p_A - c_A) = \left\{ \left[2 + (2n_A + n_B - 3)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right] [1 + (n_B - 1)\theta] - n_A n_B \psi^2 \right\} (a - c_A) \quad (28a)$$

$$- n_B \psi \left[1 + (n_A + n_B - 2)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right] (a - z)$$

$$DET2(p_B - z) = \left\{ \left[2 + (n_A + 2n_B - 3)\theta + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right] [1 + (n_A - 1)\theta] - n_A n_B \psi^2 \right\} (a - z) \quad (28b)$$

$$- n_A \psi \left[1 + (n_A + n_B - 2)\theta + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right] (a - c_A)$$

From (28), we have

$$\frac{\partial p_A}{\partial z} = \frac{n_B \psi \left[1 + (n_A + n_B - 2)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right]}{DET2} > 0 \quad (29a)$$

$$\frac{\partial p_B}{\partial z} = \frac{\left[1 + (n_A + n_B - 2)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right] \left[2 + (n_A + 2n_B - 3)\theta + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right]}{DET2} \quad (29b)$$

As in the quantity-setting case, (29b) lies between zero and one. Similarly

$$\frac{\partial p_B}{\partial z} - \frac{\partial p_A}{\partial z} = \frac{\left[1 + (n_A + n_B - 2)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right] \left[2 + (n_A + n_B - 3)\theta + n_B(\theta - \psi) + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right]}{DET2} > 0, \quad (30)$$

Whether firms set prices or quantities, an increase in e leads to a relative increase in price of foreign goods.⁶

4. Complementary Goods

The condensed reaction curves for price-setting firms slope upward when foreign and domestic varieties are complements. The intercept conditions for equilibrium prices to exceed marginal cost for firms in both countries imply, among other things, that

$$1 + (n_A + n_B - 2)\theta + n_A(n_B - 1) \frac{\theta^2 - \phi^2}{1 - \theta} \geq 0 \quad (31a)$$

$$1 + (n_A + n_B - 2)\theta + (n_A - 1)n_B \frac{\theta^2 - \phi^2}{1 - \theta} \geq 0 \quad (31b)$$

which imply that

$$\frac{\partial p_A}{\partial z} = - \frac{n_B \phi \left[1 + (n_A + n_B - 2)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right]}{DET2} < 0 \quad (32a)$$

$$\frac{\partial p_B}{\partial z} = \frac{\left[1 + (n_A + n_B - 2)\theta + n_A(n_B - 1) \frac{\theta^2 - \psi^2}{1 - \theta} \right] \left[2 + (n_A + 2n_B - 3)\theta + (n_A - 1)n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right]}{DET2} > 0 \quad (32b)$$

V. Economies of scale

1. The model

If increases in output reduce marginal cost, the effect should be to reduce the magnitude of the passthrough of exchange rate fluctuations to domestic prices. The intuition is straightforward: even if an exchange rate movement reduces the revenue that a country B firm earns from its sales in country A, the country B firm will have an incentive to maintain its sales in country A, for the sake of the cost reductions that those sales generate. This means that output will fluctuate less than would otherwise be the case. But if economies of scale reduce the impact of exchange rate fluctuations on output, they reduce the impact of exchange rate fluctuations on price.

It suffices to demonstrate this effect in the simplest possible model. Suppose one firm in country A and one firm in country B produce a homogeneous product. Assume tariffs and

transportation costs are zero, and let the cost functions of the country A firm and the country B firm be

$$C_A(q_A, x_A) = c_A(q_A + x_A) - d(q_A^2 + x_A^2) \quad (33a)$$

$$C_B(q_B, x_B) = c_B(q_B + x_B) - \delta(q_B^2 + x_B^2) \quad (33b)$$

respectively. By assuming $d, \delta > 0$, we obtain a model in which increases in output reduce marginal cost. By making these cost reductions functions of the squares of output in each country, we once again obtain a model in which country A and country B sales decisions can be analyzed separately.⁷ We also assume that d and δ are sufficiently small so that both firms produce positive outputs in equilibrium.

2. Quantity-setting equilibrium

Given our assumption that products are homogeneous, we confine ourselves to the analysis of quantity-setting behavior. The equations of the country A reaction functions are

$$2(1 - d)q_A + x_B = a - c_A \quad (34a)$$

$$q_A + 2(1 - \delta)x_B = a - ec_B. \quad (34b)$$

Solving (34), equilibrium outputs are

$$q_A = \frac{2(1 - e\delta)(a - c_A) - (a - ec_B)}{DET_A} \quad (35a)$$

$$x_A = \frac{2(1-d)(a - ec_B) - (a - c_A)}{DET_A}, \quad (35b)$$

where $DET_A = 4(1-d)(1-\delta) - 1$. We will assume that d and δ are sufficiently small so that $DET_A > 0$.

In equilibrium, total output is

$$q_A + x_A = \frac{(1 - 2e\delta)(a - c_A) + (1 - 2d)(a - ec_B)}{DET_A} \quad (35c)$$

Substituting the results into the equation of the market demand curve, Cournot equilibrium price is

$$p_A = c_A + (1 - 2d) \frac{2(1 - e\delta)(a - c_A) - (a - ec_B)}{DET_A} \quad (36a)$$

or equivalently

$$p_A = ec_B + (1 - 2e\delta) \frac{2(1 - d)(a - ec_B) - (a - c_A)}{DET_A}. \quad (36b)$$

3. Exchange Rate Comparative Statics

It is easiest to understand the impact of exchange rate fluctuations on equilibrium price by examining the impact of exchange rate fluctuations on equilibrium outputs. From

equations (35),

$$\frac{\partial q_A}{\partial e} = \frac{c_B}{DET_A} - 4\delta(1-d)\frac{a - ec_B}{DET_A^2} \quad (37a)$$

$$\frac{\partial x_A}{\partial e} = -2(1-\delta)\frac{c_B}{DET_A} + 4\delta(1-d)\frac{2(1-d)(a - ec_B) - (a - c_A)}{DET_A^2} \quad (37b)$$

$$\frac{\partial(q_A + x_B)}{\partial e} = 2(1-d)\left[-\frac{c_B}{DET_A} + 2\delta\frac{2(1-d)(a - ec_B) - (a - c_A)}{DET_A^2}\right] \quad (37c)$$

From equations (37) and for d, δ sufficiently small, an increase in e (a depreciation of the country A currency) causes the equilibrium exports of the country B firm to country A to fall, but not by as much as if returns to scale were constant. This reflects a shift in the country B reaction curve and a movement of equilibrium along the country A reaction curve. The equilibrium output of the country A firm rises, but not by as much as if returns to scale were constant. Total output falls, but not by as much as if returns to scale were constant.

The presence of economies of scale moderates the impact of exchange rate changes on output. This tends to stabilize country A price:

$$\frac{1}{1-2d}\frac{\partial p_A}{\partial e} = \frac{c_B}{DET_A} - 2\delta\frac{2(1-d)(a - ec_B) - (a - c_A)}{DET_A^2} \quad (38)$$

A depreciation of the country A currency causes the country A price to rise. But the increase

Notes

1. For simplicity, we ignore the effects of uncertainty. Hooper and Kohlhagen [1978] and Katz, Paroush, and Kahana [1982] incorporate uncertainty in models of exchange rate determination. Neither model is well suited to the examination of the connection between elements of market structure and the nature of passthrough effects.

2. Allowing for notational differences, this is the model of Spence [1976]. It can be investigated for its own sake as a generalization of the homogeneous product linear demand case, or it can be rationalized as the outcome of a utility maximization process by a representative consumer with a quadratic utility function. For discussion of the latter approach, see Kirman [1992].

3. See the equations (23) of the demand curves.

4. Since $\pi_{AI} = (p_{AI} - c_A)q_{AI}$, the equation of firm A1's reaction curve can be written in

implicit form as $p_{AI} - c_A = q_{AI} \frac{\partial p_{AI}}{\partial q_{AI}} = q_{AI}$. Similarly $p_{BI} - z = q_B$, as in (12b).

5. For concreteness, one may consider the case in which n_A domestic firms produce pairs of shoes while n_B foreign firms produce pairs of socks.

6. From (29) it is possible to calculate the comparative static derivatives that correspond to (17) and (18). The resulting expressions are too complex to be signed for general parameter

is less than would be the case if returns to scale were constant.

VI. Conclusion

The extent to which exchange rate fluctuations are passed on to domestic prices depends on substitutability/complementarity relationships among varieties produced by domestic and foreign firms and on the extent of economies of scale.

When all varieties are substitutes, the passthrough of exchange rate fluctuations rises with the degree of substitutability. A depreciation of the home country currency causes a relative increase in the prices of foreign varieties. Exchange rate passthroughs are less, all else equal, in unconcentrated markets.

If, on the other hand, foreign varieties are complementary to domestic varieties, a depreciation of the home country currency causes a reduction in the price of domestic varieties. This is the expected effect, since such a depreciation causes complementary foreign varieties to become more expensive.

Further, if firms are able to reduce marginal cost by increasing output, the impact of changes in the exchange rate on outputs and prices is reduced.

values.

7. The leading alternative specification is to let the coefficient of d be the square of total output of the country A firm and the coefficient of δ be the square of total output of the country B firm. Analysis of equilibrium in this case will yield results qualitatively similar to those presented here, but requires simultaneous consideration of all four reaction functions.

Appendix: Derivation of demand curves.

Write the system of inverse demand curves (3) as

$$\begin{pmatrix} p_A^* \\ p_B^* \end{pmatrix} = \begin{bmatrix} (a - c_A)J_A \\ (a - z)J_B \end{bmatrix} - bM \begin{pmatrix} q_A \\ x_B \end{pmatrix}. \quad (\text{A1})$$

where p_A^* is a column vector of prices of country A varieties and p_B^* is a column vector of prices of country B varieties, measured in deviations from marginal cost. J_A is a column vector of n_A ones; J_B is a column vector of n_B ones. M is the n by n square vector

$$M = (1 - \theta)I_n + \begin{pmatrix} \theta J_A J_A' & \psi J_A J_B' \\ \psi J_B J_A' & \theta J_B J_B' \end{pmatrix} \quad (\text{A2})$$

for $n = n_A + n_B$. Tedious linear algebra shows that

$$M^{-1} = \frac{1}{1 - \theta} I_n - \frac{N}{D}, \quad (\text{A3})$$

for

$$N = \begin{bmatrix} \left(\theta + n_B \frac{\theta^2 - \psi^2}{1 - \theta} \right) J_A J_A' & \psi J_A J_B' \\ \psi J_B J_A' & \left(\theta + n_A \frac{\theta^2 - \psi^2}{1 - \theta} \right) J_B J_B' \end{bmatrix} \quad (\text{A4})$$

and D given by (24). Application of the inverse matrix (A4) to the system of equations (A1) yields the demand curves (23).

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Figure 1: Condensed quantity reaction curves, Country A

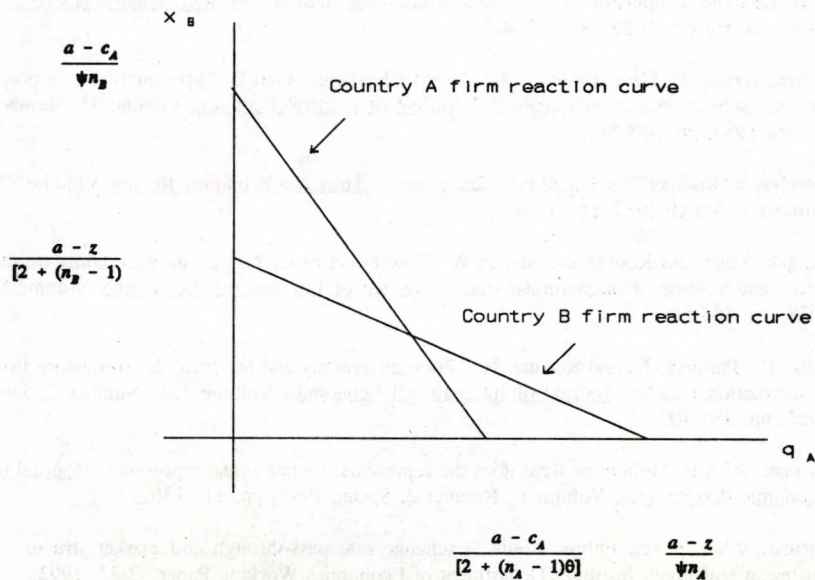
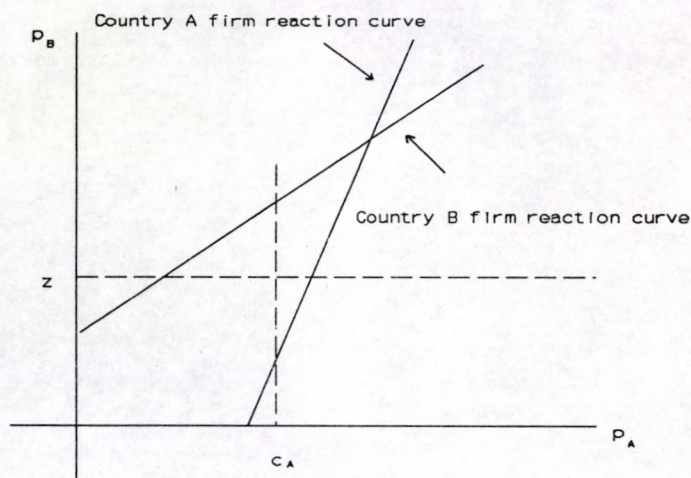


Figure 2: Symmetric reaction curves, Country A, $\theta > 0$.





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